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Impact of Ultra-High Temperature Milk on the U.S. Dairy Industry

James J. Miller

ERRATA
for
The U.S. Beef Cow-Calf Industry
AER-515

Page v, bottom of page, left hand column, paragraph on Cattle disposition should read—

Cattle disposition: Cattle sale, or feedlot placement without ownership transfer.

Page vii, left hand column, paragraph on Swather should read—

Swather: A machine that mows (clips) forage crops and accumulates the mowed plant materials into swaths or windrows.

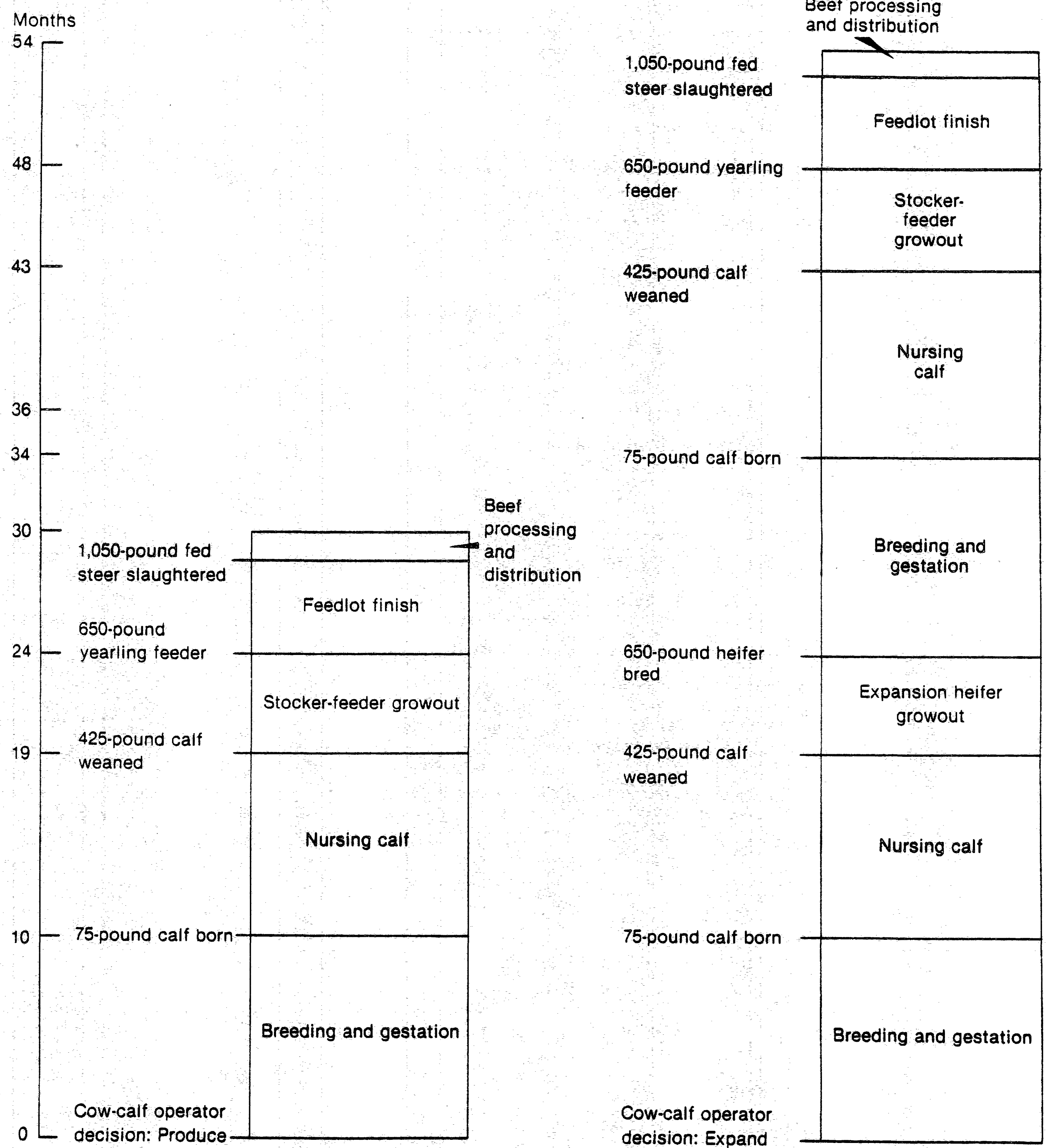
Page 20, right hand column, second paragraph is not clearly printed; it should read—

On the other hand, fall calving may be preferred, particularly in areas with mild winters and hot, humid summers. Calves born in the fall may be sold as stockers in the spring, minimizing the potentially adverse impact of heat, insects, internal parasites, and poor-quality grazing on calf gain. High-quality grazing provided by cover crops seeded in the fall is best used by calves born in the fall. Stocker calf prices are frequently higher in the spring or early summer than in the fall, due, at least partially, to the lower available volume.

Page 5, Figure 2 is incorrect, see corrected figure on back of this errata.

Figure 2

Typical Beef Production Schedule



Impact of Ultra-High Temperature Milk on the U.S. Dairy Industry, by James J. Miller. National Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 516.

Abstract

Ultra-high temperature (UHT) milk will probably not emerge as a major alternative to regular fluid milk. Although UHT can be stored without refrigeration, its retail price is higher because of the special containers it needs for long shelf life. More important, as a major product, UHT will not significantly reduce the costs of handling supply-demand variability in the milk-marketing system. The relative costs of processing, distributing, and retailing are estimated in this report with economic engineering, linear programming, and simulation techniques.

Keywords: Milk, ultra-high temperature, processing costs, distribution costs, retailing costs, supply-demand variability.

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Summary

The high cost of producing ultra-high temperature (UHT) milk will probably keep sales low, thereby impeding UHT's potential as an alternative to regular milk. The chief reason for the high cost is UHT's special containers, which have to keep out light and gases. But even if cheaper containers were developed and sales increased, UHT still would not meet a major industry goal—significantly reducing the costs of handling supply-demand variablility in the milk-marketing system.

Under three different scenarios, UHT milk cost more than regular milk, chiefly because of the added costs of its containers, and as a result attained only a small market share:

- If Federal marketing orders continue to classify UHT as a Class I use (the same class as regular fluid milk), UHT will cost about 12 percent more than regular milk and capture about 7 percent of the market.

- If UHT is classified as a Class III use (the same class as cheese and dry milk), UHT will cost about 3 percent more than regular milk and capture about 13 percent of the market.

- If UHT can be sold outside the Federal order regulations, UHT will cost about 9 percent more than regular milk and capture about 9 percent of the market.

Those are some of the conclusions detailed in this report. They are based on application of economic engineering, linear programming, and simulation techniques.

The greatest cost savings from UHT came in retailing. Elimination of refrigeration equipment was the major source of a 2.3-cent-per-gallon saving in cost of facilities. Direct variable costs for UHT milk were 1.3 cents per gallon below those for high temperature-short time (HTST) milk, primarily because of general ease of handling and the use of pallets.

UHT milk had no significant impact on distribution costs; carrying UHT milk on current HTST routes would have lower costs than separate routes. In general, specialized plants for UHT and HTST milk had about the same total processing and distribution cost as combined plants.

Processing costs, other than container costs, totaled about the same per gallon for specialized UHT and HTST plants of the same size. But, the small production would raise costs by about 2 cents per gallon.

Use of UHT stocks to handle supply-demand variation in HTST markets generally was not advantageous, except for the peak demand day of the month for milk going into HTST processing. UHT processors had strong incentive to operate at constant daily quantities during the seasonal peak demand period.This eliminated daily variability from the small portion of the market represented by UHT milk, but variability in the HTST market was largely unaffected.

Similarly, UHT processing did not have a major impact on seasonal supply-demand variation. Processors would build stocks during a few months before the seasonal demand peak, draw down those stocks during the peak months, and carry only operating stocks during the rest of the year. The optimal seasonal pattern of UHT output was very insensitive to changes in costs or prices.

Cooperatives profitably could pay UHT processors to help trim the peak seasonal surplus. Cost savings, net of additional UHT costs, were very minor—no more than a penny or two per hundredweight of milk delivered to the UHT market. Handling seasonal variation of UHT milk completely with stocks would raise processor costs by 7-23 cents per hundredweight of fluid milk.

Impact of Ultra-High Temperature Milk on the U.S. Dairy Industry

James J. Miller

Introduction

Perishability and sharp variations in supply and demand have always been the primary problems in marketing fluid milk. To solve those problems, the dairy industry has been searching for a product that could be stored inexpensively for long periods, with a flavor and retail price comparable with those of regular milk. Development of such a product would lessen or eliminate the need for the current complex regulations governing the fluid milk industry.

A new product could achieve a retail price comparable with that of regular milk by two routes:

- The new product could have lower overall production, distribution, and marketing costs.
- The new product could have higher production, distribution, and marketing costs, but could generate enough cost savings elsewhere in the marketing system by lessening the costs now incurred by the industry in continuously balancing the supply-demand variability in the market.

When ultra-high temperature (UHT) milk was first introduced, many thought it might be the product they had been awaiting. It can be stored at room temperature for up to 6 months and has a taste far superior to reconstituted milk products. But the costs of processing UHT milk appear to be too high for it to have much of an impact on the way the industry does things. The market for UHT milk will probably be small because of the high costs of the special containers needed.

Ultra-high temperature pasteurization of milk is a logical extension of the current high temperature-short time (HTST) method. HTST pasteurization heats milk to at least 161° F for 16 seconds—ridding the milk of pathogens and most quality-reducing organisms. UHT pasteurization heats the milk to more than 280° F for either a fraction of a second (direct heating) or several seconds (indirect heating). When combined with an aseptic packing system, this produces a sterile product that can be stored at room temperature for up to 6 months. Nutritional degradation is very minor, approximately the same as with HTST treatment. Flavor defects are far less than those of reconstituted milk or of earlier sterilization methods. Modern UHT milk was first introduced in Switzerland in 1961 and now holds a large market share in many West European countries (more than 20 percent in France, Germany, Italy, and Switzerland). It entered the Quebec market in 1975 with more modest success. Currently, four U.S. plants (in California, Georgia, Utah, and Washington) have introduced UHT milk.

For the consumer, UHT milk is a very close, but not perfect, substitute for HTST milk. Each type has a distinct advantage over the other. The flavor of UHT cannot consistently match that of HTST. On the other hand, storability is a definite asset for recreational use and reserve supplies of milk in the home. In addition, UHT milk will allow specialty markets (such as vending machines and the market for lactose-reduced milk) to be served much better.

Variation in the supply of and demand for fresh milk has always been a major problem for the dairy industry. Until recently, perishability of milk could not be overcome without substantially altering other important attributes of the product.Storage of milk nutrients in the greatly altered form of manufacturing products provided the first, and still most important, partial solution. Flavor defects caused poor consumer acceptance of reconstituted and sterilized milk. Therefore, storage had only limited success in overcoming the instability in milk markets, and market and regulatory mechanisms evolved to accommodate the problem.

The current milk marketing system handles the problem of supply-demand variation by short-term storage and by maintaining a flow of raw milk sufficient to cover variations. The milk not actually used for fluid products is diverted to manufacturing. The major costs of such a system are those associated with carrying enough manufacturing capacity to handle the peak quantities of surplus milk, but costs of transportation and other marketing functions are also higher.

Although seasonal differences in milk production have diminished greatly, daily output in November is less than 90 percent of the May peak for the country as a whole. The seasonal pattern of fluid milk consumption is approximately opposite that of production (a low in July and a January peak), with about the same proportional difference. The quantity of milk received under the Federal orders but not used for fluid milk is less than 60 percent as great in November as in June. Milk production follows a fairly steady seasonal pattern. However, consumer habits, particularly weekly shopping patterns, cause sharp daily and lesser weekly fluctuations in fluid sales through supermarkets.

Federal milk marketing orders and marketing mechanisms devised by processors and cooperatives have been effective in assuring that fluid milk will always be available to consumers. They also have minimized the instability that characterized milk markets until the 1930's. With the introduction of UHT, the variability problem could be handled (potentially) with rolling inventories of UHT milk, even if it captures only a fraction of the fluid market. Because of this, UHT milk poses much broader questions than those normally associated with a new product. UHT milk could alter substantially the current marketing system and cost structure for both traditional fluid milk products and manufactured dairy products.

Background

Ideally, UHT milk would be sterilized by instantaneously heating each milk particle to an extremely high, uniform temperature, followed by instantaneous cooling.[1] In practice, milk is preheated with heat exchangers to about 175° F and then sterilized between about 275° and 300° F. The most important distinction between commercially available sterilizers is between indirect and direct heating. Indirect heating is accomplished by means of plate, tubular, or scraped surface heat exchangers. Indirect heating systems are technically simpler but have the problem of surface deposits forming when milk comes in contact with metal hotter than itself. Surface deposits can interfere with heat transfer, disrupt milk flow, and add off-flavors. In the direct heating system, culinary steam (sanitary steam for direct contact with food) is injected into milk or milk is infused into the steam. Such systems operate with somewhat higher temperatures and shorter times. Evaporation in a vacuum chamber removes the added water (about a 10-percent dilution) and rapidly cools the milk. Other heating methods are feasible but are not in general use.

Aseptic (sterile) packaging equipment must form (in most systems), sterilize, fill, and seal containers in a sterile environment. Since sterile rooms are impractical under commercial conditions, aseptic packaging equipment is enclosed in a sterilized chamber. Containers are sterilized by a combination of hydrogen peroxide and heat.

UHT containers must be amenable to aseptic filling and must be able to protect quality during extended storage. Paperboard laminates are the best packages currently available. They are a sufficient barrier to gases and light, particularly if they have a layer of aluminum foil, and their cost is acceptable. Their major drawback is that sizes greater than a liter have not been developed. The stiffness of paperboard needed to give strength to a larger size jeopardizes the integrity of the seal.

The Brik-Pak container is the dominant package in current use. The container is formed inside a filler machine from a laminate consisting of paper and aluminum foil layers sandwiched between three layers of polyethylene coating. Rolls of container material and a plastic reinforcing strip are fed through a hydrogen peroxide bath and heated: the container is then filled and sealed. The rectangular package is very easy to handle in distribution but is harder for consumers to open than conventional cartons.

UHT processing slightly alters chemical, nutritional, and physical properties of milk. Heating milk partially denatures whey proteins, but this does not affect nutritive value. The loss of lysine associated with UHT treatment is about double the 1-2 percent from HTST pasteurization but far less than the 20-percent loss in evaporated milk. This loss probably is not significant nutritionally because protein from cow's milk contains excess lysine for human needs. UHT treatment liberates sulfhydryl groups from sulfur-containing amino acids, creating an off-flavor. The off-flavor is largely dissipated after about 10 days, as the sulfhydryl groups are oxidized.

[1]This section relies upon (*5*) and (*12*). Italicized numbers in parentheses refer to sources cited in the references at the end of this report.

The nutritive value of milk fat is unaffected by UHT treatment, but a higher level of free fatty acids results in significant off-flavors. The level of free fatty acids can double during sterilization and can continue to increase during storage at room temperature because of the incomplete inactivation of certain bacterial enzymes. Flavor acceptability rises substantially through the 10th day of storage as protein-related off-flavors are dissipated, then declines slowly because of off-flavors related to milk fat.

The levels of minerals and heat-stable vitamins are not affected by UHT treatment or light-protected storage. However, the loss of some vitamins (B_1, B_6, B_{12}, folic acid, and C) can be slightly greater for UHT processing, particularly with indirect heating, than for HTST processing. Further losses during storage are possible depending on the oxygen level.

Overall, nutritional degradation in processing and storing UHT milk is very minor. However, consumers may assume that nutrition is sacrificed to obtain storability. A German poll found that consumers believed UHT milk to be considerably less nutritious and to have lower levels of protein and vitamins than HTST milk.

Many taste panel experiments have been conducted with UHT milk and HTST milk. Differences in processing procedures, in length of storage, and in containers have been evaluated in blind tests using both trained and untrained panels. Most have found HTST milk to have a slightly superior flavor to directly heated UHT milk, which in turn is preferred to indirectly heated UHT milk. Variation in flavor scores is more pronounced for UHT milk, probably because of more difficult quality control in processing. In any case, flavor defects are not strongly perceived by most consumers. The addition of aluminum foil to paperboard containers generally slows the deterioration of flavor, particularly when temperature and light are not controlled in storage. UHT milk has acceptable flavor after 1-20 weeks of storage.

Consumer Acceptance in Canada

A 1976 report to the Ontario Milk Marketing Board (*6*) gave the results of the introduction of UHT into the Quebec market, measured about 6 months after introduction. Market conditions in Canada are close to those of the U.S. market. A survey showed that 55 percent of homemakers had tried UHT milk, and 18 percent were buying it regularly, at a price 10 percent higher than HTST milk. Evidently, 35-40 percent at least occasionally purchased UHT milk, including most of the 7 percent who preferred the flavor, half of the indifferent consumers, and a fifth of those who preferred HTST milk. Inconsistent flavor quality was reported to be a problem. The initial 30-percent market share in stores where it was available had declined to 12-15 percent within about 6 months. The estimated share for the total market was 5-10 percent.

Thirty homemakers were given enough UHT milk to fill their fluid milk needs. A fourth to a third were satisfied with the flavor (no objections from any family member). Homemakers liked the convenience of UHT milk, particularly the diminished frequency of shopping, but noted some difficulty in opening and handling the cartons.

Processing Costs

Earlier economic engineering estimates by Wood (*13*) and Fischer et al. (*1*) provided basic data on the costs of processing UHT and HTST milk for use in this study. Wood (*13*) used economic engineering to analyze four sizes of plants producing indirectly heated UHT milk, ranging in capacity from 65,625 to 603,750 gallons per week on a 6-day processing schedule. Production was assumed to be constant for each operating day of the year. Costs were calculated according to prices in late 1980 for North Carolina.

The model plants used sterilizing equipment manufactured by Cherry-Burrell and Brik-Pak filling equipment. The product mix consisted of whole, 2-percent, 1-percent, skim, and chocolate milk and half-and-half, packaged in quart, multiquart, and (except for the smallest plant) half-pint units. The distribution by container size and product was based on Federal order data.

The equipment, land, and building needs were developed in cooperation with equipment manufacturers and consulting engineers. An interest rate of 15 percent was used. Buildings and equipment were assumed to have an economic life of 20 years and no salvage value. Buildings were designed to meet the recommendations in (*11*) with appropriate modification for UHT milk production. Enough warehouse space in the main building to provide for a 10-day storage period was included. Taxes, insurance, administrative, and Brik-Pak maintenance costs were included in fixed costs for assessing the impact of utilization of capacity on costs.

Wood made no attempt to capture seasonal patterns or cost interactons with HTST processing. In addition, the exclusion of distribution costs made determination of optimum plant size impossible. Within the scope of the study, the only apparent omission was the lack of an interest charge for the normal 10-day storage period. Such a charge would add about two-thirds of a cent per gallon to all sizes.

The estimation of processing costs (in *1*, by Fischer et al.) was very similar to that used by Wood. Model plants processing 50,000, 200,000, and 400,000 gallons a week were designed. Recommendations for space and equipment and assumed schedules of receipts, processing, and sales from (*11*) were followed. Prices were quoted as of late 1977-early 1978 and were most applicable to Minnesota. An interest rate of 10 percent and straight-line depreciation were used. Equipment had an economic life of 15 or 20 years, while 33 years was used for buildings. The impact of seasonality on average fixed cost was not assessed.

On the basis of these two studies, processing costs of UHT milk were about double those of HTST milk. The difference in total processing costs was roughly equal to the difference in costs of containers and packaging materials. Economies of size were proportionately greater for HTST, particularly for small plants. UHT plants were relatively more capital-intensive than HTST plants. In both studies, the increase in average cost associated with excess capacity was proportionately greater for small plants than large.

Data and Methodology

A variety of linear programming and simulation models were used to predict seasonal production patterns, intraweek production patterns, distribution costs, retailing costs, and demand relationships. The questions relating to cost were chosen for analysis on the basis of potential significant differences between the two products (not covered in the economic engineering studies), potential cost interactions between UHT and production of HTST or manufactured products, or policy importance.

Seasonal production of UHT milk (unlike that of HTST milk) can be controlled by the processor. Stocks of UHT milk can be substituted (in effect) for carrying processing capacity greater than needed for all but the highest demand period of the year. Seasonality of UHT milk production also affects costs of manufacturing seasonal milk reserves. Differences in seasonality between the two products directly affect relative capital and other processing costs.

In a combined plant, UHT output could be varied inversely to HTST output, thus reducing daily variability in raw mik demand and minimizing capacity costs that are independent of the product mix. Significant cost interactions between UHT milk and HTST milk would provide an advantage to combined plants over specialized plants and could have important policy ramifications.

A plant producing both products could distribute UHT milk on HTST routes or on a separate route. Similarly, individual plants could specialize in one product or all plants could process both. Plant specialization generally reduces processing costs but almost always increases distribution costs. The pattern with the lowest weighted average cost ultimately will prevail.

In the retail store, the need for refrigerating HTST milk increases handling costs as well as adds energy and equipment costs. Because UHT milk can be merchandised as a dry grocery item, potential differences in cost are substantial.

The difference in costs of supplying UHT milk and HTST milk at a given market share (and therefore in retail prices) is the sum of the difference in processing costs (adjusted for seasonality and specialization), any objective difference in distribution costs, and the difference in retailing costs.

Data

Processing costs were derived directly from Wood (*13*) and Fischer et al. (*1*). All costs are as of 1980; the HTST cost data were indexed forward by means of published changes in fluid milk margins. Discrepancies between the studies were made comparable on an item-by-item basis. A 15-percent interest rate was assumed unless otherwise stated.

The average cost equation from Lasley and Sleight (*2*) was used to estimate savings in balancing costs. An estimate of the minimum cost associated with full use of capacity was derived from estimated average processing costs in 1980 and the capacity use level implied by the seasonality of milk production.

Data on producer deliveries, milk use by class, and milk prices were taken from *Federal Milk Order Marketing Statistics* (*10*). Milk prices were for 1980, but the 1978-79 average use data were used to avoid any distortion induced by the recent heavy surpluses. The data were regionalized on the basis of the eight Federal order areas. Class I use was adjusted for calendar composition by means of published adjustment factors for fluid milk sales (*7*). Producer deliveries and use in Classes I and II were standardized to 30-day months. Class III use was a calculated residual.

Seasonal Model

Optimal seasonal patterns of production and storage were based on a linear program. The model evaluated the tradeoff between the costs of storage (both fixed and variable) and the costs of underutilization of processing capacity, incorporating price incentives to store. This represents a base scenario under which UHT milk is priced as Class I, and the processor can do nothing to alter the price paid for raw milk.

The milk prices used were constructed from the 1980 average Minnesota-Wisconsin (M-W) manufacturing grade milk price and factors obtained by using the seasonal adjustment program of the Bureau of Labor Statistics (U.S. Department of Commerce). These prices were then lagged 2 months, as in the Federal order Class I calculations. Prices during the storage year also reflected a 10-percent annual uptrend. For a particular market area, the start of the storage year was defined as the first month with sales below the annual average.

The model coefficient on processing capacity (8.3841) represents the total annual fixed cost shown in Wood (*13*), expressed on a hundredweight-per-month basis. Similarly, the coefficient on storage capacity (3.6041) reflects the annual cost of the building space needed to store 1 hundredweight of UHT milk. An interest charge is the only significant cost of storing UHT milk beyond the normal 10 days. The monthly interest cost for each market area was calculated on the sum of the M-W price, the local Class I differential, and Wood's estimate of UHT processing costs. Interest costs ranged from 22.9 to 24.4 cents per hundredweight per month at a compound annual rate of 15 percent. Seasonality of demand was assumed to be the same for UHT milk as HTST milk.

The seasonal pattern of UHT production will have a direct impact on the costs of manufacturing the milk not needed for the fluid market. Therefore, the results from the previous model may not be optimal for the market as a whole. Cooperatives could offer payments or discounts to a processor who agreed to process and store UHT milk in such a way as to reduce cooperative balancing costs. Minimum processing levels were calculated so that the average monthly surplus was a given percentage of the maximum monthly surplus. This percentage was raised in increments of 2.5 points to measure changes in processor costs. Changes in producer revenues caused by shifts in the seasonal purchase pattern were also calculated.

The percentage of manufacturing capacity utilized was then used to calculate manufacturing costs. Changes in per-unit manufacturing costs were converted to total cost savings based on the annual volume of surplus milk in the market area. The approximate optimal solution was the last increment where the decline in balancing costs (net of changes in producer revenues) exceeded the increase in processing costs.

Lastly, a seasonal pattern of UHT production corresponding to seasonality in farm milk production was imposed on the model. This pattern would eliminate the need for seasonal reserves of raw milk and would be a potential industry response if the Federal marketing orders were eliminated. It also represents the situation where a specialized UHT firm could organize a supply network of independent milk producers whose annual output equaled its annual needs. This arrangement could be mutually advantageous if the increase in processor cost per hundredweight was less than the local cooperative's over-order premium. Unlike the traditional free rider problem, such a network would operate independently from the rest of the market. Neither the processor nor the producer would benefit from cooperative market balancing. In fact, manufacturing costs for the cooperative would be reduced, partially offsetting the loss of overorder payments. Savings in manufacturing costs were calculated as shown above.

Intraweek Model

A substantial proportion of total investment in a specialized UHT or HTST plant consists of facilities that could be used for the other product. The sharp variation in daily HTST production results in underuse of every type of needed capacity. In a combined plant, variation in HTST output could be offset by varying UHT production during the week, thus minimizing the underuse of capacity used for both. Whether or not this is cost-minimizing depends on the relative building and equipment costs of joint and specialized UHT capacity.

A mixed integer model was used to derive an optimal pattern of weekly production for a combined plant during the peak demand period. The coefficients represented the combined and specialized UHT investment required per gallon of daily capacity for a plant with a combined output of 300,000 gallons per week, but varying mixtures of the two products.They were developed by segregating the itemized equipment and space requirements shown in the two economic engineering studies into categories representing specialized UHT capacity, specialized HTST capacity, and combined capacity. In a few cases (boiler systems and raw milk storage, for example), the investment was split between specialized and combined categories because only a portion of that investment is needed for the other product. Investment independent of peak daily quantities (primarily general plant overhead) was excluded. Different coefficients on specialized UHT capacity represented the marginal investment requirements between the sizes used by Wood.

This model was run with two different processing schedules for HTST milk. The first schedule was that used by Fischer et al. (*5*), which in turn was based on (*11*). The assumed raw milk delivery, processing, and sales schedules did not correspond to more recently reported data on deliveries to plants or sales by day of the week. Therefore, a 5-day processing schedule was developed, consistent with the aggregate quantities processed according to (*9*).

The ratio of UHT milk production to total plant output ranged from 20 to 80 percent and was increased by increments of 10 percentage points. Some of these levels could not be sustained economically by individual plants because of the large unit size of the UHT filling equipment. Therefore, the model provided a closer representation of the situation for a multiplant industry than for an individual plant.

The normal weekly processing schedules represented average daily levels. The actual levels vary greatly in response to unforeseeable variations in consumer sales or miscalculations by the processor or retailers. When stocks of packaged milk rise (or fall), these holdings must quickly be returned to normal levels by reducing (or increasing) the flow of milk through processing equipment. This represented another type of variation for which inversely varying UHT output could compensate. It was assumed that variation in the quantities processed was proportional to variation in the amount of milk that processors took from the milk reserve. A random sample of 10 plants was drawn from the data used by Lasley (*2*). Data for each plant showed actual plant receipts for October. Daily volumes were then indexed to the 4-week average for that plant. For each plant, differences were taken from its particular average weekly pattern and then were pooled across plants to obtain an estimated standard deviation. This standard deviation and the normal processing schedule—based on (*9*)—were used to generate three 4-week processing schedules. Each schedule reflected random variation with an approximately normal distribution, except that daily averages across weeks were constrained to equal the normal weekly schedule. The intraweek model was then expanded to handle these HTST schedules and was run with UHT accounting for 20, 40, and 60 percent of total plant output.

Distribution Costs and Specialization

The results of the preceding model were used to calculate fixed costs of combined plants and weighted combinations of specialized plants for various relative levels of UHT production. Variable costs were assumed to be specific to the type of product produced and were added to fixed costs. This provided an estimate of the economies of specialization for plants processing a total of 300,000 gallons weekly. Such economies represent economies of size in variable costs and specialized investment, minus any savings in fixed costs attained by offsetting HTST variation.

A generalized model of distribution costs that accurately predicts distribution patterns based on minimizing costs is virtually impossible to develop. A processor can only hope to approximate an optimum based on the specific size and location of existing and potential outlets. Thus, distribution costs were handled with a simulation based on an even spatial distribution of equal-sized outlets. Average route characteristics and data relating to important components of distribution costs were taken from (*1*).

Under the assumed even distribution of consumption, the competitive solution is a honeycomb pattern of exclusive distribution areas, with plants of equal size located at the centers of the cells. This pattern formed the base solution for combined plants. Plants were then designated as specializing in either HTST or UHT production. Market shares for UHT of 25 and 50 percent were used.

Increases in distribution costs associated with making both products available to each outlet were calculated using the indicated increase in duration and mileage of routes and marginal vehicle and labor costs. Backhauls were used where feasible. Specialization would be expected where the economies of specialization exceed the weighted increase in distribution costs.

Costs of Retailing

The COSMOS model was used to establish cost differences in retailing UHT milk and HTST milk.[2] The two major categories were direct variable costs (primarily

[2]The COSMOS (Computer Optimization and Simulation Modeling for Operating Supermarkets) model (*4*) was developed as a system to help chainstore managers maximize profit. Using parameters for a typical aggregate store, the model can predict costs for new items or compare costs of alternative procedures.

labor) and costs related to facilities (cost of building and equipment directly committed to the product plus an allocation of overhead costs). Direct variable costs included unloading the processor's truck, backroom handling, movement to the aisles, case opening, price marking of individual units, shelving, case disposal or handling, and checkout and associated services. UHT milk was assumed to be handled on pallets as far as possible, and the coefficients were adjusted to reflect the specific characteristics of UHT pallets. Shelving was done by tray instead of by individual unit. Handling methods for HTST milk already in the model were used. The sizes used were half-gallon and gallon for HTST milk and 1, 2, 3, and 4 quarts for UHT milk. The larger units of UHT milk were several 1-quart packages prewrapped in plastic film.

The costs related to facilities included utilities, building and equipment depreciation, other building costs, equipment repairs, insurance, equipment rental, and general business taxes. Costs of the building space and equipment directly used for display and storage of the product were calculated. In addition, costs of building and equipment overhead (such as checkout area) were allocated according to sales volume. Costs were based on 1980 prices.

UHT milk was treated as a dry grocery item sold from shelves. Shelf area was calculated so that trays of whole, lowfat, and skim UHT milk were displayed. Sufficient space was allocated to ensure that each product would need to be stocked no more than once a day. The empirical results already in the model of HTST milk were used. These reflect typical layout and facilities for refrigerated display and storage.

Movement of UHT milk was set to reflect a share of 7-8 percent of the total milk movement. At these quantities, the restriction of dealing in tray units imposed a slightly lower turnover rate than could be attained with larger quantities, particularly for the slower moving skim milk.

Demand Relationships

Demand relationships, particularly substitution relationships, cannot be quantified for a new product. However, there are two important cornerstones upon which to build an assumed set of demand relationships: the current characteristics of HTST demand and the experience of other countries with UHT demand.

It was assumed that the new two-product group would have an aggregate price elasticity similar to the current price elasticity of HTST milk. In addition, price responsiveness varies little among regions, and the same level was assumed for all regions. Since the availability of UHT milk allows some portions of the fluid market to be served better, a slight increase in total fluid sales was assumed. If UHT milk was sold at an equal price, an increase of 1 percent of the total market was used. Total fluid sales were expressed as a function of a weighted fluid milk price, which used constant weights.

The relationship of market share to relative prices can be compared across countries. However, factors other than relative prices have been important. UHT milk sales have been boosted where the prevalence of refrigeration in the home was relatively low and where HTST milk quality was lower. Even so, results in other countries did provide a general guide to the expected outcome here, especially those of Canada where the market preconditions most closely match the U.S. situation. These data indicated that the elasticity of substitution was very high, which would be expected for close substitutes. The functional form chosen results in a doubling of market share in response to a decline of 0.1 in the ratio of UHT price to HTST price. Market penetration in Quebec lies on this curve while observations in those countries where preconditions favor UHT milk (France and Italy, for example) lie somewhat above the curve.

Using data for the U.S. aggregate, the assumed demand functions were:

$$U = (MS)\,T$$

$$F = (1 - MS)\,T$$

$$\ln T = 4.28377 - .15\,(.15\,P_u + .85\,P_f)$$

$$\ln MS = \ln(.15) + \ln 1024\left(1 - \frac{P_u}{P_f}\right)$$

where:

U = sales of UHT milk (billion pounds)

F = sales of HTST milk (billion pounds)

T = total sales (billion pounds)

MS = market share of UHT milk

P_u = price of UHT milk (dollars per gallon)

P_f = price of HTST milk (dollars per gallon)

These equations resulted in UHT sales of 15 percent of the total after full adjustment to equal prices. Proportional changes in both prices will generate proportional changes in sales. The price elasticity for the group was −0.30 at a weighted price of $1.99 per gallon (the 1980 HTST prices). The HTST price was held at $1.99, and the UHT price was allowed to fluctuate to evaluate changes in market share according to policy alternative.

Determination of Equilibrium

An average U.S. retail price was calculated by weighting the price for a half gallon (as reported by the Bureau of Labor Statistics) with the average price for a gallon (as reported by the International Association of Milk Control Agents and internal reports of Federal order market administrators). Proportions of fluid sales by container size (reported for November 1979 (*8*)) were used as weights to obtain a U.S. average price for 1980 of $1.99 per gallon. The implied average margin was then used to construct a retail price surface based on minimum Class I prices.

Information from the previous models was aggregated across levels to obtain aggregate differences in the costs of marketing UHT and HTST milk, allowing for differences in market share and region where the data permitted. These differences and the average HTST margin were combined to form a set of marketing margins. This procedure assumed that intermediate prices would reflect differences in costs.

The farm price of milk going into UHT milk was determined by policy alternatives. The policy alternatives used were classification as Class I, classification as Class III, and regulation of milk going into HTST production only. The price paid for UHT milk was assumed to be the Federal order blend price if UHT milk prices were unregulated. The farm milk price plus margins generated a set of potential retail prices.

The market share in a particular region was determined by the intersection of retail prices and the demand function. A solution was found for each policy alternative and market.

Results

UHT milk is not likely to have a radical impact on the U.S. industry. The costs of exploiting its technological potential generally outweigh the advantages. With sharply higher container costs, about the same processing and distribution costs, modest savings in costs of retailing, and minor effects on the costs of maintaining raw milk reserves, longrun retail prices of UHT milk will average higher than those of HTST milk—regardless of Federal order classification. Sales of UHT milk probably will be small at such premium prices.

Optimal Seasonal Pattern

The seasonal model indicated that UHT milk processors would use seasonal stocks to reduce needed UHT capacity. However, savings in fixed costs and seasonal price incentives were clearly insufficient to induce uniform seasonal output of UHT milk (table 1). The results vary considerably across regions because of divergent seasonal patterns, but a general pattern emerged. Production was increased to a fall-winter plateau 2-5 months before the demand peak and remained there until sales fell below that plateau. Stocks rose during the first portion of this period and then fell, although some deviation from this pattern occurred because of the holiday-induced drop in sales in December. During spring and summer, only enough UHT milk was produced to meet current sales; it was less costly to carry excess capacity than stocks for the tight season. Therefore, the capacity needed to manufacture the seasonal surplus would be unaffected by a shift from HTST milk to UHT milk. Ironically, UHT milk could make autumn market conditions even tighter than they currently are in some markets, since UHT milk processors then would be attempting to build stocks for the winter.

The results for the East North Central region illustrate the general pattern. Daily average sales in these markets hit a seasonal low of 91 percent of the annual average in July and then rise to a peak of 106 percent in January. A UHT processor would minimize costs by producing just as much as was sold during April-August. Production would jump to 103 percent in September and would run at full capacity through March. Stocks would rise slowly during September-November, absorb all of the December drop in sales, and then be used to meet the heavy January-February needs. The amount of surplus in June (the heaviest month) would be unaffected by UHT milk production. However, production would run about one-half percent more than sales during November—the month with tightest milk supplies.

The lack of storage in response to seasonal price rises was not surprising. Average seasonal rises in raw milk prices are ultimately defined by costs of manufactured product storage. Since storage costs are less for manufactured products than for UHT milk, storage of UHT milk simply on the basis of seasonal price rises is

Table 1—Seasonal UHT production and stocks, by region and scenario

Item	Sales	Base Processed	Base Stocks[1]	Market optimum Processed	Market optimum Stocks[1]	Independent supply Processed	Independent supply Stocks[1]
	Percent of average monthly sales						
North Atlantic:							
January	105.3	103.2	0.9	103.2	0.9	98.3	4.8
February	104.2	103.2	—	103.2	—	99.4	—
March	101.6	101.6	—	101.6	—	102.8	1.2
April	100.4	100.4	—	100.4	—	106.4	7.2
May	99.3	99.3	—	100.7	1.4	109.0	16.9
June	94.6	94.6	—	96.1	2.8	106.5	28.8
July	91.0	91.0	—	88.2	—	98.9	36.7
August	93.8	93.8	—	93.8	—	97.0	39.9
September	102.2	103.2	1.0	103.2	1.0	96.9	34.6
October	102.9	103.2	1.4	103.2	1.4	94.8	26.5
November	103.2	103.2	1.4	103.2	1.4	93.7	17.0
December	101.6	103.2	3.0	103.2	3.0	96.4	11.8
Total[2]	1,200.0	1,200.0	7.7	1,200.0	11.9	1,200.0	225.4
Capacity[3]	105.3	103.2	3.0	103.2	3.0	109.0	39.9
South Atlantic:							
January	106.2	105.8	1.4	105.6	1.8	104.4	1.5
February	107.2	105.8	—	105.6	.2	105.7	—
March	105.8	105.8	—	105.6	—	108.6	2.8
April	103.3	103.3	—	105.0	1.8	107.8	7.3
May	98.7	98.7	—	99.7	2.7	103.7	12.3
June	92.9	92.9	—	91.9	1.8	96.7	16.1
July	91.9	91.9	—	90.1	—	89.7	14.0
August	92.3	92.3	—	92.3	—	90.3	12.0
September	97.8	99.5	1.8	100.5	2.7	92.8	7.0
October	99.1	97.4	—	96.4	—	95.5	3.3
November	103.1	103.1	—	103.1	—	100.5	.8
December	101.9	103.6	1.8	104.2	2.4	104.4	3.3
Total[2]	1,200.0	1,200.0	5.0	1,200.0	13.4	1,200.0	80.4
Capacity[3]	107.2	105.8	1.8	105.6	2.7	108.6	16.1
East North Central:							
January	106.3	103.1	1.4	102.2	3.1	95.9	7.9
February	104.5	103.1	—	102.2	.9	98.5	1.9
March	103.1	103.1	—	102.2	—	101.2	—
April	101.5	101.5	—	101.5	—	104.8	3.2
May	98.6	98.6	—	99.0	.4	108.5	13.1
June	92.8	92.8	—	99.6	7.2	108.5	28.7
July	90.8	90.8	—	88.7	5.2	102.8	40.8
August	94.4	94.4	—	95.4	6.2	100.4	46.8
September	102.6	103.1	.5	102.2	5.8	97.4	41.6
October	102.7	103.1	.9	102.2	5.3	95.0	33.9
November	102.7	103.1	1.4	102.2	4.9	92.9	24.1
December	100.0	103.1	4.5	102.2	7.2	94.1	18.3
Total[2]	1,200.0	1,200.0	8.7	1,200.0	46.2	1,200.0	260.3
Capacity[3]	106.3	103.1	4.5	102.2	7.2	108.5	46.8

See footnotes at end of table.

Continued

Table 1—Seasonal UHT production and stocks, by region and scenario—Continued

Item	Sales	Base		Market optimum		Independent supply	
		Processed	Stocks[1]	Processed	Stocks[1]	Processed	Stocks[1]
				Percent of average monthly sales			
West North Central:							
January	106.0	104.1	—	102.0	2.1	98.0	3.2
February	104.1	104.1	—	102.0	—	100.9	—
March	101.6	101.6	—	101.6	—	104.1	2.5
April	100.6	100.6	—	100.6	—	107.5	9.4
May	96.5	96.5	—	102.0	5.5	109.6	22.5
June	90.3	90.3	—	100.4	15.6	108.9	41.1
July	89.8	89.8	—	81.6	7.4	100.9	52.2
August	95.6	96.6	1.0	102.0	13.6	94.7	51.2
September	103.7	104.1	1.3	102.0	12.0	91.8	39.2
October	104.0	104.1	1.5	102.0	10.0	92.6	27.8
November	105.6	104.1	—	102.0	6.4	93.5	15.8
December	102.2	104.1	1.9	102.0	6.2	97.7	11.3
Total[2]	1,200.0	1,200.0	5.7	1,200.0	79.0	1,200.0	276.2
Capacity[3]	106.0	104.1	1.9	102.0	15.6	109.6	52.2
East South Central:							
January	98.7	98.7	—	98.7	—	95.9	1.3
February	99.9	99.9	—	99.9	—	98.6	—
March	99.9	99.9	—	99.9	—	99.9	.1
April	99.5	99.5	—	103.6	4.2	106.1	6.7
May	97.1	97.1	—	99.2	6.3	102.9	12.6
June	92.2	92.2	—	94.0	8.1	99.4	19.7
July	93.9	94.3	.4	89.6	3.9	96.7	22.6
August	99.5	105.1	6.0	103.7	8.1	99.9	23.1
September	108.7	105.1	2.4	104.4	3.8	102.0	16.4
October	107.5	105.1	—	104.4	.7	99.9	8.9
November	105.1	105.1	—	104.4	—	98.8	2.6
December	98.3	98.3	—	98.3	—	99.7	4.1
Total[2]	1,200.0	1,200.0	8.8	1,200.0	35.1	1,200.0	118.1
Capacity[3]	108.7	105.1	6.0	104.4	8.1	106.1	23.1
West South Central:							
January	105.5	102.4	.4	102.7	—	99.5	4.4
February	102.8	102.4	—	102.7	—	98.3	—
March	100.7	100.7	—	100.7	—	103.7	3.0
April	100.6	100.6	—	102.7	2.1	110.0	12.4
May	98.2	98.2	—	98.0	1.9	106.3	20.4
June	93.0	93.0	—	91.1	—	100.3	27.7
July	93.3	93.3	—	93.3	—	95.0	29.4
August	97.2	100.7	3.5	99.8	2.5	95.8	28.1
September	104.0	102.4	1.9	102.7	1.3	97.3	21.4
October	104.0	102.4	.4	102.7	—	98.0	15.4
November	102.8	102.4	—	102.7	—	96.8	9.4
December	98.1	101.6	3.5	100.9	2.9	99.1	10.5
Total[2]	1,200.0	1,200.0	9.7	1,200.0	10.7	1,200.0	182.1
Capacity[3]	105.5	102.4	3.5	102.7	2.9	110.0	29.4

See footnotes at end of table.

Continued

Table 1—Seasonal UHT production and stocks, by region and scenario—Continued

Item	Sales	Base		Market optimum		Independent supply	
		Processed	Stocks[1]	Processed	Stocks[1]	Processed	Stocks[1]
		Percent of average monthly sales					
Mountain:							
January	102.1	102.1	—	101.9	0.2	93.9	7.9
February	102.1	102.1	—	101.9	—	95.9	1.7
March	101.5	101.5	—	101.5	—	99.8	—
April	99.0	99.0	—	99.0	—	102.9	3.9
May	97.6	97.6	—	99.6	2.0	104.4	10.7
June	91.7	91.7	—	96.8	7.1	103.3	22.3
July	92.8	92.8	—	94.6	8.8	101.2	30.7
August	98.7	102.9	4.2	98.7	8.8	100.8	32.8
September	103.5	103.5	4.2	101.9	7.3	100.3	29.6
October	105.7	103.5	2.0	101.9	3.5	100.8	24.8
November	105.4	103.5	—	101.9	—	98.8	18.1
December	99.8	99.8	—	100.1	.3	97.8	16.1
Total[2]	1,200.0	1,200.0	10.4	1,200.0	37.8	1,200.0	198.6
Capacity[3]	105.7	103.5	4.2	101.9	8.8	104.4	32.8
Pacific:							
January	102.1	102.1	—	101.2	—	92.9	7.3
February	101.0	101.0	—	101.0	—	94.5	.8
March	98.6	98.6	—	98.6	—	97.8	—
April	99.7	99.7	—	99.7	—	102.7	3.1
May	98.3	98.3	—	99.7	1.4	106.8	11.6
June	93.4	93.4	—	100.0	8.0	106.6	24.9
July	92.0	92.0	—	96.2	12.2	105.2	38.2
August	99.0	102.4	3.5	99.0	12.2	103.1	42.3
September	103.8	103.8	3.5	101.2	9.6	100.0	38.5
October	104.9	103.8	2.4	101.2	5.9	98.0	31.5
November	106.3	103.8	—	101.2	.8	95.8	21.0
December	101.0	101.0	—	101.2	.9	96.5	16.5
Total[2]	1,200.0	1,200.0	9.4	1,200.0	51.0	1,200.0	235.7
Capacity[3]	106.3	103.8	3.5	101.2	12.2	106.8	42.3

— = no stocks.
[1]At end of month.
[2]May not add due to rounding.
[3]Needed capacity defined as maximum in any month.

unlikely. Month-to-month raw milk price changes altered production only when excess capacity existed for both UHT milk production and storage.

The results did not show a consistent geographical pattern, indicating that the optimal pattern for an individual market could deviate from that for the region. The reduction in UHT processing capacity was greatest in areas with a sharp demand peak. The impact of UHT stocks was fairly minor in all areas; it was felt most strongly in the East South Central region. But even there, processing capacity was reduced by the equivalent of less than 4 percent of average monthly sales, and stocks never exceeded 6 percent.

The model was run with interest rates ranging from 9-18 percent and with the cost ratio of processing capacity to storage capacity varying widely. The basic seasonal patterns were virtually unaltered by these changes. In most markets, there was a single 1-month change across the entire spectrum in the number of months with stocks. This insensitivity to parameters conflicted with intuition at first glance. However, both the total product-months of storage and required storage capacity rise very slowly in response to an initial reduction in processing capacity but rise very rapidly with additional reductions. In the East North Central region, for example, a further reduction of UHT capacity to 102 percent of annual average sales would lessen, rather than increase, the need for seasonal milk reserves. However, interest costs of storage would be almost five times larger than the optimal, and costs of storage capacity would almost double. The cost savings of capacity reductions are almost constant. Under these circumstances, substantial changes in costs per unit may have little effect on the optimal seasonality of production.[3]

A UHT processor could process milk during the peak seasonal surplus and store it for later use with a relatively small increase in cost, since the base solution showed slack processing capacity at that time. Cooperatives profitably could offer incentives to a processor who helped reduce the peak seasonal surplus of milk. The optimal degree of surplus reduction was where the difference between reductions in manufacturing costs (net of changes in producer revenue) and increases in costs to processors was greatest.

Processors would build stocks during the peak seasonal surplus and reduce them as quickly as possible. However, processing capacity was less than that of the base solution in all market areas (except the North Atlantic and West South Central regions) because stocks associated with the surplus could not be worked off by the time of seasonal building of stocks. The flattening of the seasonal surplus from the UHT market would raise average use of capacity in plants manufacturing that surplus by about 5-10 percentage points.

The net savings to the market were small. They ranged from 0.4 cent per hundredweight of milk delivered to the UHT market in the North Atlantic region to 1.8 cents in the East North Central region (table 2). In fact, savings in some markets may not be great enough to overcome the risks of legal or regulatory problems associated with arrangements between cooperatives and fluid plants. However, this seasonal pattern would be expected for UHT plants owned by cooperatives.

Price inducements could be used in lieu of negotiated agreements to alter processing schedules. However, losses in producer revenue would overwhelm savings in manufacturing cost long before changes in processor behavior would be induced.

When the model was forced to produce UHT milk according to the seasonal pattern of farm milk production, processor costs rose sharply, even though their weighted average price for raw milk was lower. Cost increases ranged from 7.3 cents per hundredweight processed in the East South Central region to 22.6 cents in the West North Central region. Rises in cost were greatest in northern markets, followed by western markets. End-of-month stocks could be rotated within 16 or fewer days in all cases. Therefore, meeting seasonal needs entirely from stocks would present no significant technical or flavor problems, but would require greater processing capacity in most markets.

Manufacturing costs to the cooperative actually were reduced substantially without a seasonal surplus from the UHT market. However, there was a net loss to market participants. These losses ranged from 2.4 cents per hundredweight of milk delivered in the East South Central region to 9.3 cents in the West South Central region. These losses can be viewed as the result of pushing the use level of manufacturing capacity far beyond the optimal level determined in the previous scenario.

In a market where processors paid only minimum Federal order prices, this production pattern would not be expected. Ample incentive would exist if a processor could avoid overorder payments to cooperatives; such premiums averaged 62 cents per hundredweight in 1980. Processors who equated their annual needs with the annual output of a group of independent producers and processed UHT milk as raw milk was available would eliminate the major risk and costs of an independent supply for HTST milk—finding a temporary source or outlet for extra milk. The processors and their producers would not be free riders; they would receive no benefit from the cooperative's balancing services.

Although the incentive for processors to organize independent producers appeared large in many markets, such an outcome is not assured. Processors would have to replace the production of farmers who leave dairying and drop dairy farmers or find outlets for milk during surplus periods. They would also have to compensate dairy farmers for the lower weighted prices, the loss of any portion of the overorder revenue that the cooperatives returned to producers, and the loss of other cooperative services. The results showed that such arrangements certainly could arise, but it is by no means certain that they will.

[3]The following situation is a close—but farfetched—analogy to the problem. Suppose a contractor is paid for every foot he removes from the height of a mountain. His costs for the first foot of reduction are very low. However, both the amount of rock he has to move and the distance he must go to dump the rubble into the valley grow sharply with each additional foot of reduction. The last foot removed will always represent a major share of his total cost. Substantial changes in the payment rate or the cost of moving rock a given distance would strongly affect profits from the job, but the number of feet he could profitably remove may change very little.

A pattern of UHT milk production that requires no market balancing would be one likely response to an elimination of Federal orders. The industry might even find it easier to convert entirely to UHT milk production than to undergo the long and unsettling evolution of market mechanisms to replace the Federal order system.

Optimal Intraweek Pattern

Using either processing schedule, the intraweek model showed that UHT milk should be produced in uniform daily quantities. This was true for every ratio of UHT milk to total milk processed. These results indicated that it is less expensive to carry excess joint capacity than excess UHT capacity. A reduction of one unit of joint capacity on the peak day for HTST processing would require an increase of one-fourth unit in UHT capacity, implying an initial break-even ratio of joint fixed costs to UHT fixed costs of 1:4. The actual ratio was about 1:8.

The standard deviation estimated from the Lasley data on plant receipts (adjusted for day of the week) was +26.8 percent of the average daily level (*2*). For example, a Tuesday with a variation of (+1) standard deviation would exceed a normal Tuesday level by an amount equal to 27 percent of the average level of the 20 days. The extremes of the distributions were set at ±60 percent.

The results from the randomized processing schedules did show some influence of HTST variability on UHT processing. The results varied by the relative amounts of UHT processed and by the particular randomized schedule. However, they consistently fit a pattern of reducing UHT processing on the day of the month with peak HTST output until the joint capacity needed for the peak HTST day equaled that needed for the second-highest HTST day. UHT milk was processed in uniform quantities during the remaining 19 days (table 3).

Compensation for the peak day of the month was possible because of the larger number of days available to replace the deficit and the resulting smaller required increase in UHT capacity. Conceivably, situations could arise where costs would be reduced by limiting UHT output on the two highest HTST days, but the coefficients did not quite indicate that pattern.

The model indicated a 5-percent increase in UHT capacity in a plant producing 20 percent UHT milk. The percentage boost in capacity dropped to 4 at 40 percent UHT production. The cost savings for the plant were tiny, about a half cent per hundredweight or less than 0.05 cent per gallon.

The model could predict a processing schedule only for the period of peak seasonal demand, when annual capacities were determined. It should not be assumed that similar schedules would hold during periods of general

Table 2—Impacts of alternative UHT seasonal processing schedules

Region	Market optimum				Independent supply				
	Change in:[1]				Change in:[1]				
	Processor cost	Producer revenue	Balancing cost	Net savings[2]	Processor cost	Producer revenue	Balancing cost	Net savings[2]	Change in processor cost[1]
	Cents/cwt delivered to UHT market[3]								*Cents/cwt UHT sold*
North Atlantic	[4]	[5]	−0.5	0.4	9.3	−0.7	−3.8	−6.2	18.1
South Atlantic	0.4	0.1	− .9	.6	6.8	.1	−2.3	−4.4	8.0
East North Central	.3	− .2	−2.2	1.8	9.0	−1.0	−5.4	−4.7	19.1
West North Central	1.2	− .2	−2.5	1.1	8.2	− .5	−4.7	−4.0	22.6
East South Central	.3	− .1	−2.0	1.6	5.3	− .5	−3.4	−2.4	7.3
West South Central	.2	.2	− .8	.7	12.6	− .2	−3.5	−9.3	16.3
Mountain	.5	− .1	−2.3	1.8	7.6	−1.2	−4.8	−4.0	15.9
Pacific	.6	− .2	−2.4	1.6	7.7	−1.1	−4.8	−3.9	15.9

[1]From base solution.
[2]To all market participants (does not include any loss of overorder revenue); may not add due to rounding.
[3]Total market deliveries times market share of UHT.
[4]Positive but less than 0.05 cent.
[5]Negative but absolute value less than 0.05 cent.

excess capacity. There probably would be a tendency to produce equal total quantities during such periods. This would level out daily quantities of labor and other inputs treated as variable costs. On the other hand, arrangements between processors and cooperatives, similar to those developed by the seasonal model, could be used to alter daily and weekly patterns. Some sort of accommodation would be likely during the peak surplus period, when capacity for manufacturing is defined and UHT processors have ample surplus capacity.

Both the seasonal and intraweek models treated capacities as completely fixed. In fact, capacities can be defined only loosely. The length and number of labor shifts, milk flows, and other processing and marketing procedures are altered, especially to handle extreme variations. Even so, models using capacity costs (defined under normal operating procedures) can predict general patterns—but not with the precision the techniques would imply. This is particularly true where cost savings are as small as those shown by the intraweek model.

Many processor costs associated with daily variation cannot be quantified adequately. These probably are greatest during the seasonally tightest market conditions. Therefore, the model probably understates the dampening of variation associated with HTST production and the cost savings that would occur in combined plants.

Distribution Costs and Specialization

Most of the economies of size (especially for HTST milk) came from costs of equipment related to the total size of the plant and not from specialized UHT or HTST costs. Economies of specialization were far smaller than economies of size because costs like general plant overhead, receiving space and equipment, and most raw milk storage were independent of the product mix for a plant of a given size. However, economies of specialization in processing were significant.

One specialized UHT plant and three specialized HTST plants (each processing 300,000 gallons a week) yielded a weighted average processing cost 0.6 cent per gallon lower than that of four combined plants. At a market share of 50 percent, the savings were very similar—0.7 cent per gallon.

The quantity of milk carried on a route of a given length and number of stops had an insignificant impact on total costs. The costs of a van required for the average route would be the same as or higher than those of a tractor-trailer with twice the capacity (5). Eliminating refrigeration on UHT routes would generate further slight savings (5). These savings would be largely offset by higher labor costs associated with longer unloading times and more difficult handling, particularly in urban traffic.

Table 3—UHT processing schedules and cost savings with randomized HTST processing schedules

HTST processing schedule	UHT processed[1]			Change in fixed cost of:[2]		Net savings	
	Per week	Peak day[3]	Other days	Joint capacity	UHT capacity		
	1,000 gallons			*Dollars/year*			*Cents/gallon*[4]
I	60.00	0.49	12.61	−12,972	7,683	5,288	0.03
II	60.00	0	12.63	−13,519	8,007	5,512	.04
III	60.00	10.56	12.08	−1,627	964	663	*
I	120.00	15.37	24.45	−9,718	5,863	3,855	.02
II	120.00	7.95	24.85	−18,087	10,913	7,175	.05
III	120.00	22.92	24.06	−1,220	736	484	*
I	180.00	30.24	36.30	−6,486	3,144	3,342	.02
II	180.00	25.29	36.56	−12,062	5,846	6,216	.04
III	180.00	35.28	36.04	−813	394	419	*

* = less than 0.005.
[1]Based on plant with average combined UHT and HTST volume of 300,000 gallons/week.
[2]From a uniform daily UHT processing schedule.
[3]Day of month with greatest demand for milk for HTST.
[4]UHT and HTST milk combined.

This situation has led to the conclusion that costs of specialized delivery of UHT milk could be half those of specialized delivery of HTST milk, if trucks of twice the size delivered half as often (5). Although inherently correct, this conclusion can mislead by not comparing a dual delivery system with a combined system. The marginal costs of delivering UHT milk to stores on the same truck used for HTST milk would be insignificant; the costs of the alternative, using separate routes for each, would be substantial. Thus, a combined distribution system would be expected for a plant producing both products.

The smaller quantities of HTST milk to be delivered after the introduction of UHT milk will not lower HTST delivery costs because of route consolidation. Route consolidation after UHT milk is introduced will reduce costs only where it would have done so without UHT delivery. The capacity of the trucks had almost no bearing on route costs, except where the largest available size of truck (about twice the capacity needed for the average route) was used.

A specialized UHT plant would find it less costly to use an existing distribution network than to deliver directly to stores. Backhauls on either HTST routes or chainstore grocery routes would result in very low distribution costs for UHT milk. However, specialized UHT plants would be mutually dependent on specialized HTST plants, which would have to increase their distribution areas (with an attendant increase in average distribution costs) or lose economies of size. Specialized plants would exist only where the weighted average costs of processing and distribution were lower than for combined plants. The experiment run under conditions of equal spatial distribution of delivery points was inconclusive. For the average route, the added distribution costs just slightly exceeded the savings in processing costs; the added costs were less only where consumption density was very high (table 5). These savings were less than a fifth of a cent per gallon with a density twice that of the average route.

In general, plants producing both types of milk and distributing through combined routes probably have a slight edge over specialized plants, on the basis of both costs and organizational simplicity. If the market share of UHT milk was insufficient to allow all plants to produce it, some plants would produce both and the remainder would be specialized HTST plants. However, the diversity of distribution conditions certainly would allow specialization to be profitable in some circumstances. High consumption density or economies of specialization in the production of perishable manufactured products could swing the balance. In any case, weighted costs of processing and distribution will not vary much from those of a totally combined operation.

Costs of Retailing

Direct variable costs per gallon fell substantially as unit size increased for either product. Costs of handling 4-quart units of UHT milk were only half those of han-

Table 4—HTST and UHT processing costs, by plant size

Item	HTST			UHT				Combined
				Gallons/week				
Plant capacity	50,000	200,000	400,000	65,625	150,940	301,875	603,750	[1]
				Cents/gallon				
Fixed cost at full capacity	11.6	6.6	5.0	13.3	11.2	9.1	7.9	9.5
Average fixed cost[2]	12.3	7.0	5.3	13.8	11.6	9.5	8.1	9.9
Container cost	12.9	12.7	12.7	32.1	35.4	35.4	35.4	35.4
Other variable cost[3]	11.4	9.2	8.6	12.5	8.1	7.3	6.2	9.0
Seasonal storage cost[4]	na	na	na	.1	.1	.1	.1	.1
Total[5]	36.6	28.9	26.6	58.5	55.2	52.3	49.8	54.4

na = not applicable.
[1]Capacity for 65,000 gallons of UHT milk and 235,000 gallons of HTST milk.
[2]Based on U.S. average capacity use rates of 94.3 percent for HTST milk and 96.6 percent of UHT milk.
[3]Includes U.S. average cost of operating capital.
[4]U.S. average; includes both fixed and variable costs.
[5]May not add due to rounding.

Table 5—Increase in distribution cost associated with specialized plants[1]

Number of stops	Gallons per route		
	1,200	1,831[2]	2,400
	Cents/gallon		
Route length of 81 miles:[2]			
6	2.0	1.3	1.0
10	1.6	1.1	.8
15	1.4	.9	.7*
21	1.2	.8	.6*
28	1.1	.7*	.6*
36	1.0	.7*	.5*
Route length of 50 miles:			
6	1.3	.9	.7*
10	1.1	.7*	.6*
15	1.0	.6*	.5*
21	.9	.6*	.4*
28	.8	.5*	.4*
36	.8	.5*	.4*
Route length of 120 miles:			
6	2.8	1.8	1.4
10	2.2	1.5	1.1
15	1.9	1.3	1.0
21	1.7	1.1	.8*
28	1.5	1.0	.7*
36	1.4	.9	.7*

*Specialized plants were potentially profitable.
[1]Cost difference between specialized plants and plants producing both UHT and HTST milk; assumes evenly distributed delivery points and plants, a UHT market share of 25 percent, and use of backhauls for UHT delivery.
[2]Average reported in (*1*).

dling individual quart packages, even thought packages were not shelved individually (table 6). For HTST milk, costs associated with gallon packages were almost a fourth less than those associated with half-gallons. Differences in per-gallon costs among package sizes were chiefly the result of differences in checkout labor and miscellaneous costs required, but differences in costs of price marking and shelving were significant in some instances.

Direct variable costs of UHT and HTST milk were based on a composite of half-gallon and gallon sizes. Weights were based on reported sales by container size (*8*). UHT milk cost considerably less in unloading and backroom handling (table 7) because it is shipped on pallets. HTST costs were increased by the need to rotate stocks within the relatively confined refrigerated storage area. Shelving and disposing of shipping containers costs significantly less for UHT milk. The cost advantages of UHT milk was partially offset by the costs of removing the plastic wrap from around the trays. Direct variable costs totaled 7.4 cents per gallon for UHT milk, compared with 8.7 cents per gallon for HTST milk.

The cost advantage of UHT milk was highly sensitive to package size. Processors might use a 3-quart wrap for UHT milk instead of a 4-quart wrap, so the price per package would be less than that of a gallon of HTST milk. This would eliminate a half cent of the cost advantage of UHT milk. UHT milk could even have a cost disadvantage if relatively high proportions were sold in 1-quart or 2-quart units.

The greatest UHT cost savings to the retailer came from eliminating refrigeration. Fixed costs for UHT milk

Table 6—Direct variable cost of retailing UHT and HTST milk, by package size

Operation	UHT 1 qt	UHT 2 qt[1]	HTST 1/2 gal	UHT 3 qt[1]	UHT 4 qt[1]	HTST 1 gal
	Cents/gallon					
Unloading	0.1	0.1	0.7	0.1	0.1	0.8
Backroom movement	.1	.1	.7	.1	.1	.8
Movement to selling area	.1	.1	.1	.1	.1	.1
Opening cases	.6	.6	0	.6	.6	0
Marking prices	.9	.7	.5	.7	.6	.5
Shelving	1.2	1.2	1.9	1.2	1.2	1.4
Disposal of shipping material	1.1	1.1	1.3	1.1	1.1	1.4
Checkout	7.8	4.3	4.3	3.1	2.5	2.5
Other	1.5	.8	.8	.5	.4	.4
Total[2]	13.4	8.9	10.2	7.4	6.7	7.9

[1]1-quart packages prewrapped as a single unit.
[2]May not add due to rounding.

Table 7—Costs of retailing UHT and HTST

Item	HTST	UHT	Savings with UHT
	Cents/gallon[1]		
Direct variable cost:			
Unloading	0.8	0.1	0.7
Backroom movement	.8	.1	.7
Movement to selling area	.1	.1	0
Opening cases	0	.6	−.6
Marking prices	.5	.6	−.1
Shelving	1.6	1.2	.3
Disposal of shipping material	1.4	1.1	.3
Checkout	3.1	3.1	0
Other	.5	.5	0
Total[2]	8.7	7.4	1.3
Cost of facilities:			
Utilities	1.0	.1	.9
Depreciation	1.0	.3	.7
Other building cost	.5	.4	.1
Equipment repair	.5	.1	.4
Insurance, equipment rental, and taxes	.3	.1	.2
Total[2]	3.3	1.0	2.3
Total retail cost[3]	12.0	8.4	3.6

[1]Weighted averages of half-gallon and gallon sizes.
[2]May not add due to rounding.
[3]Does not include interest on operating capital and some overhead costs.

consisted primarily of the costs of the space it occupied plus its share of overhead. On the other hand, HTST milk also incurred substantial costs of refrigeration equipment and utilities to operate it.

Significant savings were attained by UHT milk in utilities, depreciation, equipment repairs, and equipment rental. Costs for facilities for UHT milk totaled 1 cent per gallon, compared with 3.3 cents per gallon for HTST milk. Total retail savings in direct variable costs and facilities costs were 3.6 cents per gallon.

Because of relatively high turnover rates, both products would make a significant contribution to store profits as long as a relatively restricted line of UHT products was sold. Proliferation of brands, sizes, or types of UHT milk would boost retailing costs sharply. A doubling of UHT volume would allow substantial diversification of the product line without greatly reducing cost savings.

Equilibria

The retail price of UHT milk in 1980 would have been more than 23 cents per gallon above the HTST price, if longrun cost differences were fully reflected in prices and if milk for UHT were classified as Class I under the Federal orders. The ratio of UHT to HTST prices was almost 1.12, roughly the same as the relative prices reported for the Quebec market. Under the assumed demand relationships, this relative price would have resulted in a market share for UHT milk of just under 7 percent (table 8). Total fluid milk sales would have increased about 200 million pounds, less than one-half percent.

Regional differences under this alternative were insignificant. Relative UHT prices were slightly lower (and market shares slightly higher) in markets outside of the Midwest. However, this was almost entirely because the relatively constant difference in UHT and HTST prices represented a smaller share of the higher general price level.

About a tenth of the difference between UHT and HTST prices was the result of the small market share of UHT milk. The small volume required either small-scale production or higher distribution costs to attain economies of specialization.

Most of the difference in retail prices would be eliminated if milk for UHT were Class III. Retail UHT prices would average less than 3 percent higher than HTST prices. The market share of UHT milk would reach almost 13 percent. This alternative would result in total fluid sales rising by almost 1 percent from a market without UHT milk.

Annual producer revenues would be about $138 million less than if UHT milk were Class I (table 9), but consumer expenditures would not be significantly affected. Class III would allow consumers to exploit the advantages of UHT milk without paying more. Compared with Class I or a fluid market without UHT milk, Class III essentially would shift a portion of consumer expenditures from dairy farmers to producers of UHT inputs, particularly packaging materials.

Absolute UHT prices were essentially uniform across regions, but relative UHT prices fell with distance from the upper Midwest. UHT prices were about the same as HTST prices in the South Atlantic region but were almost 6 percent higher in the West North Central region. The corresponding variation in market share was from about 15 percent to 10 percent.

If specialized UHT processors were not regulated but had to pay the Federal order blend price to remain competitive for raw milk supplies, the retail price and market share for UHT milk would fall between those for Class I and Class III. UHT prices would average about 7 percent above HTST prices, and the market share would be about 9 percent. Total fluid sales would be two-thirds of a percent greater than without UHT milk.

Regional patterns under this alternative were not neat because of the interaction between the level of the Class I differential and Class I use. UHT milk would be most competitive in a market with a relatively large differential and relatively low fluid use. In general, the size of the differential and the use percentage are positively correlated in Federal order markets. The retail price premium for UHT milk ranged from almost 10 percent in the South Atlantic region to just over 6 percent in the North Atlantic region. The corresponding market shares went from less than 8 percent to almost 10 percent. UHT milk was generally less competitive in the South than in the West or North.

Producer revenues for unregulated UHT milk were lower than with UHT milk in Class I but were considerably higher than with a Class III decision. They were $46 million per year lower than in the Class I alternative, only a third of the drop associated with placing UHT milk in Class III. Consumer expenditures were roughly the same.

These results do not reflect the impact of interregional shipments of UHT milk. Unregulated prices would increase the price incentives for shipment, and UHT milk could use relatively inexpensive transportation alternatives not available to HTST milk. Even so, price differences were not sufficient to generate significant interregional flows. Shipment of small quantities could be expected where UHT milk could use especially inexpensive transportation, like backhauls.

Implications

UHT milk presents a classification dilemma for the Federal order system. It has definite fluid milk characteristics and probably will share the benefits of the fluid milk reserve. Yet, it does not require reserves of raw milk and probably will help to balance the HTST market.

The Class I differential in the area of greatest surplus production has three major parts: an incentive to produce Grade A milk, a part to help cover the costs of maintaining the fluid milk reserve, and a part that represents market discrimination between the fluid and manufacturing markets. The allocation of the differential among the three parts is disputed. However, it does form a useful framework in which to analyze the classification problem.

Agencies responsible for sanitary regulation have already decided that UHT milk must be produced from Grade A milk. Therefore, the incentive needed to call forth Grade A production logically would apply. This incentive is now fairly small. Even so, some incentive is required for an individual producer to meet Grade A standards; it must at least cover the inconvenience of periodic inspection.

UHT processors generally will rely on seasonal reserves of milk. In many markets, they actually may worsen seasonal fluctuation by producing just enough to meet current sales during the peak surplus and then attempting to build stocks during the tightest part of the year.

Table 8—Equilibrium retail prices and market shares of UHT milk by region and policy option

Region	Retail price of HTST	Retail price of UHT milk			Market share of UHT milk		
		Class I[1]	Class III[1]	Unregulated	Class I[1]	Class III[1]	Unregulated
	Cents/gallon				*Percent*		
U.S. average	198.7	221.9	203.8	213.3	7	13	9
North Atlantic	202.0	225.2	203.8	214.8	7	14	10
South Atlantic	204.1	227.4	204.0	224.0	7	15	8
East North Central	194.1	217.2	203.8	210.1	7	11	8
West North Central	193.0	216.2	203.8	208.3	7	10	9
East South Central	198.0	221.2	204.0	216.7	7	12	8
West South Central	201.0	224.1	203.7	219.5	7	14	8
Mountain	199.9	223.1	203.8	216.8	7	13	8
Pacific	197.1	220.2	203.8	211.7	7	12	9

[1]Regulatory treatment of milk for UHT in Federal order markets.

Table 9—Impact of classification decision on sales, producer revenue, and consumer expenditures

Item	Unit	Class I[1]	Class III[1]	Unregulated[1]
UHT sales	Bil. lb	3.6	6.8	4.8
HTST sales	Bil. lb	50.0	47.0	48.8
Total fluid milk sales	Bil. lb	53.6	53.8	53.7
Change in producer revenue[2]	Mil. dol.	na	−138	−46
Change in consumer expenditures[2]	Mil. dol.	na	−6	11

na = not applicable.
[1]Regulatory treatment of milk for UHT in Federal order markets.
[2]From classification as Class I.

There is a sharp divergence between what UHT processors could do to reduce seasonal reserves and what they are likely to do.

The situation with operating reserves is much different. UHT processors already have incentive to produce constant quantities on the days they process. Presumably, nonprocessing days easily could be spread among UHT plants, so that the operating reserves needed by the UHT market would be quite small. Stocks would cut the linkage between consumer shopping patterns and processing schedules. In addition, combined plants may use UHT milk to modify extreme variations in HTST markets. Overall, UHT production would lessen the quantities of milk needed for operating reserves and the costs of maintaining those reserves.

To be equitable, UHT plants should share the costs of maintaining milk reserves to the extent that they benefit from them. While that would argue for some differential for milk going into UHT, it also raises a question of equity. A uniform differential to all HTST plants is appropriate since they receive relatively uniform benefits from milk reserves. But UHT plants could be operated so that they require almost as large a reserve as HTST plants, require no reserve at all, or even carry part of the HTST reserves. A uniform differential would diminish the ability of market participants to negotiate mutually advantageous arrangements. It might be desirable to allow cooperatives to recoup the costs of the UHT reserve through payments above the Class III price. This obviously would present problems in markets without a dominant cooperative. In addition, UHT processors likely could avoid overorder payments more easily than HTST processors.

The question of whether or not UHT plants should pay the third part of the differential reduces to the question of whether or not such revenue enhancement is socially desirable. Pricing milk for UHT as Class III would break down segregation of the fluid and manufacturing markets. The relative elasticities of Class I and Class III could be sharply altered. The only way to attain the current level of revenue enhancement would be to assure that net producer returns from the UHT market equal those from the HTST market.

If plants pay the same price for milk for both UHT and HTST, retail prices would reflect the net difference in processing, distribution, and retailing costs. Consumer expenditures for fluid milk would be higher than currently, but consumer welfare would be improved. The cost savings from the reduced needed reserves would accrue to dairy farmers. Both consumers and milk producers would be better off than previously. This would not be the case if milk for UHT carried the same price as milk for manufacturing. Consumer welfare would be substantially improved, but producer revenues would be reduced considerably. Overly simplified, each gallon of UHT milk substituted for a gallon of HTST milk would shift revenues from milk producers to container manufacturers.

The Federal order program sets only minimum class prices. Considerable variation in relative prices potentially exists for any Federal order classification. Actual outcomes will depend heavily on cooperative policies, actions, and bargaining strengths as well as Federal order decisions.

UHT and the Need for Marketing Orders

The introduction of UHT milk sharply alters the policy question surrounding the continued existence of Federal orders. Until now, the argument has centered on whether or not the system can handle variability in the fluid milk market more efficiently and equitably than the market mechanisms that would evolve without the order system. There is now a third alternative. UHT milk could handle its own variability and some or all of the variability of HTST milk.

Stocks of UHT milk are not a cheap way of handling variability. The solution to the independent supply scenario provides an indication of the costs of using stocks of UHT milk to handle its own variability—approximately 10 cents per hundredweight of UHT milk. If the total fluid market was UHT, costs of handling variability with UHT stocks would fall within the range of estimates of net social costs of the Federal order system.

Handling all the variability with UHT milk represents an extreme case. The cost-minimizing solution in the absence of Federal orders probably would be a combination of balancing with UHT stocks and traditional balancing with manufactured products. Use of UHT stocks would lower the cost of balancing without the order system and thereby lower the benefits of the system.

The Federal order system probably is not a significant hindrance to the adoption of UHT technology. The adoption rate is not likely to be much different than if Federal orders had never existed. However, their elimination would spur adoption of UHT technology. Dropping the system after decades of use would induce a great deal of (at least shortrun) disruption. Evolution of market mechanisms to replace the order system would be extensive and costly. Processors very well could find heavy or total conversion to UHT technology to be the easiest and quickest way to adjust. Once established, the dominance of UHT technology could be hard to break, even if some other solution were better in the long run.

UHT milk may force a reevaluation of the industry truism that consumers must always have HTST milk available. This has been accepted for many years because consumers tended to view milk as a needed staple and the industry found that out-of-stock situations led to a decline in sales. Having UHT milk available as a very close substitute would go a long way toward removing this urgency. Allowing occasional out-of-stock situations would substantially diminish variability in the HTST market and disproportionately reduce costs of the system.

Impact on Industry Structure and Competition

Structural change probably would accelerate if UHT milk becomes an important part of the fluid industry. Small plants would face greater survival problems because they would be effectively locked out of the UHT market. More than half of the plants in 1979 (predominantly local, single-plant firms) lacked sufficient volume to use one aseptic filler efficiently (3). Only about a fourth of the plants were large enough to have both a quart and a half-pint filler. Many multiunit operations could consolidate to attain required volumes, but single-unit firms would be especially vulnerable. Small plants would have to be specialized HTST plants, while medium-sized plants would be either specialized in HTST production or predominantly UHT production. Fewer than a tenth of the current plants are large enough to offer a full range of products from their own production. Small and medium plants would have to incur the costs of an interplant marketing system or bear a competitive disadvantage. They might also be more vulnerable to abuse of market power. Plants owned by food chains might benefit most by UHT adoption. These integrated plants have sharply increased their market share and have the largest median size. In addition to their size advantage, they have much more flexibility in distribution.

UHT technology also may encourage further integration into processing by cooperatives. Use of UHT milk to reduce balancing costs would be more easily accomplished within a firm than through contractual arrangements. Cooperatives may be especially attracted to specialized UHT operations.

The large minimum size for UHT processing would make it more difficult for new firms to enter the market. The investment needed for an efficient combined operation will be quite large. While it would remain possible to enter as a small, specialized HTST plant, some arrangement with a UHT operation would be needed to provide a full product line.

Structural changes because of the introduction of UHT milk might imply reduced competition in the fluid industry. However, the storable character of UHT milk would enhance competition in several ways. UHT milk could help forestall abuse of market power by a locally dominant cooperative. Processors would not necessarily be dependent on the balancing services of the cooperative. They could use alternative local or distant sources of milk; it would no longer be required to have milk available quickly.

Time would become a much less binding constraint on the transportation of packaged milk. The risks and costs of product loss and delay in shipment would be greatly diminished. A temporary excess can be held for future use instead of reshipped. Lower cost transportation, such as rail, barge, or backhauls on unrefrigerated trucks, would become feasible. All these factors tend to lower the total cost of movement and enhance competition by increasing the number of potential competitors in any market.

Competition could also be improved at the retail level. Retailers other than foodstores have sold HTST milk, but the required investment in refrigeration, inexperience in handling such a product, or low volumes have limited the appeal. All establishments retailing soft drinks could be potential outlets for UHT milk. Home delivery routes with a low frequency of delivery might even be profitable. Such alternative outlets would lessen the market power of supermarket chains.

Overall, UHT milk probably would increase competition in the system. The flexibility of a storable product and the broadening of potential markets are likely to override accelerated concentration, incentive for vertical integration, and more difficult entry. However, the use of UHT technology may open up niches in the market that an individual firm profitably could enter to the detriment of the system. For example, overorder premiums are necessary in some markets to compensate for the fact that the transportation costs reflected in Federal order minimum prices have not been updated in over a decade. A processor using an independent supply system to avoid these overorder payments would benefit from the adequate local supply, pay none of the costs of maintaining that supply, and add to the total costs of the system.

Adoption and Shortrun Adjustment

The large threshold capacity and the market risks of introducing a generally premium-priced substitute probably will result in slow and uneven adoption. Initial UHT processors will tend to emphasize actions that reduce shortrun risks, even at the cost of some longrun profitability. Other HTST processors and market participants probably will wait to gauge consumer acceptance before making any adjustments.

Initial penetration probably will be made by a few dispersed UHT plants that will introduce UHT milk in most markets through special distribution networks and marketing agreements. Initial retail price premiums probably will be much greater than the indicated longrun cost differences because of much higher distribution, retailing, and processing costs, limited competition, and pricing strategies. Market penetration probably will be greatest in isolated, high-priced markets like Alaska.

Wide dispersal of plants with correspondingly broad distribution areas lessens the risk for initial investors. Certain plant locations can reduce risk further. Relatively easy access to export markets appears to have been an important consideration in the location of the first plants in Washington, California, and Georgia. The longrun competitive export position of U.S. UHT processors is not promising. U.S. producers will have difficulty competing with subsidized European or inexpensive Oceanic milk. However, access to export markets could be quite valuable in the short run, utilizing capacity as the domestic market develops or minimizing losses if UHT milk fails here. Similarly, easy access to sources of fruit juice can lessen risk. The same equipment can be used to produce UHT juice. Processing both milk and juice spreads the risk between two markets. In fact, the market for UHT juice may be more promising. In contrast to milk, UHT containers are less costly and lighter than the currently used cans or bottles. In Europe, UHT juices are firmly entrenched, even in countries where UHT milk sales are weak. Access to the export market and sources of fruit juice probably will be important considerations in the location of the first plants.

The period immediately following the introduction of a new product is crucial, particularly if the product is priced higher than the traditional alternative. Effective (and generally expensive) promotion campaigns must be devised to induce trial purchases by consumers. Consumers must be made aware of the product's unique advantages as well as its availability. Quality control is both critical for longrun consumer acceptance and particularly difficult during this phase. Lack of experience with the technology increases the risk of poor-quality product. Negative first impressions created by poor quality can be difficult, if not impossible, to overcome.

After the initial penetration, there probably will be a gap (possibly prolonged) before further adoption. If a UHT market develops, plants will emerge along the seams of the previous UHT distribution areas. For competitive reasons, adoption may be completed in some individual markets before starting in others. Relative prices could vary greatly during this second stage of adoption. In general, UHT costs will remain above longrun levels. However, prices could drop below costs to minimize the losses associated with temporary overcapacity.

Organization and adjustment of the market to exploit the advantages of UHT milk probably will lag adoption of the technology, at least where interfirm arrangements are involved. Participants will want assurance of the viability of the product and a rough idea of its ultimate importance before starting the largely trial-and-error process of altering market mechanisms. Given the nature of the technology and the difficulties of adjustment, at least 15-20 years is needed to see if UHT milk will be an important dairy product.

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Appendix—Federal Milk Marketing Orders

Federal milk marketing orders are local entities established by milk producer referenda and administered by the Secretary of Agriculture. The inability of market mechanisms to handle variation in supply-demand conditions for fluid milk without chronic stability and equity problems led to passage of enabling legislation during the 1930's. The explicit objectives of the legislation are rather nebulous references to "adequate supplies" and "orderly marketing." Important objectives of the program include maintaining milk reserves sufficient to cover the tightest market conditions and curtailing opportunities for processors or producers to avoid their share of the costs of the reserve.

The two basic mechanisms used in Federal orders are regulating minimum prices according to the products for which the milk is used (classified pricing) and pooling of revenues among producers. Some States also have established milk marketing orders that are very similar to the Federal orders.

Fluid milk products are classified as Class I. The perishability of these products requires that raw milk be available to cover variability. On the other hand, milk for storable manufactured products (such as butter, nonfat dry milk, and cheese) goes into Class III (Class II in a few markets), since supply-demand variation can be absorbed by stocks. In markets with three classes, Class II is an intermediate class for such products as cream, cultured products, and ice cream. These manufactured products are perishable but have a considerably longer storage life and greater ingredient flexibility than fluid products.

Milk that is ineligible for use in fluid products because it is not produced in accordance with Grade A sanitary standards lies outside the scope of Federal order regulation. The Minnesota-Wisconsin (M-W) manufacturing grade milk price is the best representation of the competitively determined value of such milk. The M-W price is used as the price for Grade A milk used in Class III products under the Federal orders. The minimum Class I price is the M-W price plus a differential. This differential increases with distance from the upper Midwest (the area with the greatest milk production in excess of fluid needs). The Class II price is just slightly above the Class III price and is uniform across markets.

Revenues from the various uses are pooled so that every covered producer in a Federal order market receives the same price, regardless of how the milk they produced was actually used. The only deviations are specified adjustments for the fat content of the milk and distance from the major urban center(s) in the market. The minimum blend price which plants must pay producers in a given month is calculated by weighting the class prices by the proportion of milk used in each class in the market as a whole. Revenue is transferred among plants so that each is able to pay the blend price, and each effectively pays the minimum price for milk it uses in a particular class.

Cooperatives may obtain premiums above the Federal order minimum prices. These over-order payments generally apply to Class I usage and are not pooled with members of other cooperatives or nonmembers.

Demand for fluid products is less elastic than demand for manufactured products. The two markets are separated fairly completely by differences in product form and use. Therefore, Class I differentials in excess of the costs of maintaining the fluid reserve represent a classic case of price enhancement through market discrimination.

Further details on Federal and State fluid milk regulations can be found in *Government's Role in Pricing Fluid Milk in the United States* (C. N. Shaw and S. G. Levine, AER-397, U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, 1978).

Markets Included in Federal Order Regions

North Atlantic
- New York-New Jersey
- Middle Atlantic
- New England Regional

South Atlantic
- Georgia
- Upper Florida
- Tampa Bay
- Southeastern Florida

East North Central
- Michigan Upper Peninsula
- Southern Michigan
- Eastern Ohio-Western Pennsylvania
- Ohio Valley
- Indiana
- Chicago Regional
- Central Illinois
- Southern Illinois
- Louisville-Lexington-Evansville

West North Central
- Upper Midwest
- Eastern South Dakota
- Black Hills
- Iowa
- Nebraska-Western Iowa
- Greater Kansas City
- St. Louis-Ozarks
- Neosho Valley
- Wichita

East South Central
- Tennessee Valley
- Paducah
- Memphis
- Nashville

West South Central
- Central Arkansas
- Fort Smith
- Oklahoma Metropolitan
- Red River Valley
- Texas Panhandle
- Lubbock-Plainview
- Texas
- Greater Louisiana
- New Orleans-Mississippi

Mountain
- Eastern Colorado
- Western Colorado
- Great Basin
- Lake Mead
- Central Arizona
- Rio Grande Valley

Pacific
- Puget Sound
- Inland Empire
- Oregon-Washington

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